CHIME
Connecticut’s Model for National Healthcare Informatics Infrastructure:
Network, Web EDI, PKI, and Data Mining

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“CHIME” was established in 1980 by the Connecticut Hospital Association’s Research Foundation (CHREF) as a program for coordinating the collection and distribution of Health Care data. In 1996, CHIME was formally incorporated as a for-profit affiliate of the Connecticut Hospital Association. The principal products of CHIME include CHIME-Data, CHIME-Report, CHIME-NET, CHIME-Link, CHIME-Trust, and RxInfo.
NIST ATP Projects

• Healthcare Information Infrastructure Technology (HIIT)
  ATP 94-04 (70NANB5H1011) 3/95-2/98
  – CHREF JV partner for Healthcare testbed and EDI

• Healthcare Information Technology Enabling Community Care (HITECC)
  ATP 95-10 (70NANB5H1195) 11/95-10/98
  – CHREF JV Partner for MPI, security testbed

• RxInfo: Data Mining Tools for Assessing the Impact of Pharmaceutical Therapies on Population Based Healthcare Outcomes
  ATP 97-03 (70NANB7H3035) 3/98-2/2001
  – CHIME Lead Organization

RxInfo Goals

• To develop tools and reports that would enable healthcare practitioners and researchers to evaluate drug therapies based on past clinical experiences at hospitals and healthcare settings.

• To pursue technology associated with outcomes-based data mining of pharmacy data.

• To pursue new technologies for the delivery and utilization of pharmaceutical information.
Healthcare Scenario #1

- Jenny, 14 year old, has an asthma attack
- Patient arrives at physician’s walk-in clinic
- Physician’s clerk connects to HMO via Web.
- Clerk identifies self using smart card key #1.
- HMO identifies self using server key #2.
- HMO server authenticates clerk using public directory
- Clerk requests eligibility using HMO web-enabled mainframe
- Eligibility encrypted to clerk using public key #1.
- Clerk decrypts using private key #1.
Healthcare Scenario #2

- Patient signs permission for records.
  - Release **scanned** into file (no Fax).
  - File encrypted, **e-mailed** to hospital Medical record administrator key #3
  - Record Administrator decrypts request for records using private key #3
    - Administrator locates records.
    - Administrator encrypts to MD Key #4.
    - Administrator e-mails records to MD.
    - MD decrypts records using private key #4

Healthcare Scenario #3

- Physician loads patient history into his **handheld practice guideline**
  - Guideline recommends Prednisone
  - Physician queries **data mine** for results of last 1000 patients with similar conditions
    - Query results also indicate success with prednisone
      - Query results communicated from local server to handheld.
**Healthcare Scenario #4**

- Physician writes electronic script.
- MD issues check against HMO formulary
- HMO denies coverage from Brand name. Recommends generic alternative.
- MD alters script accordingly.

**Healthcare Scenario #5**

- MD signs script using private key #4
- **Digital signature** bound to script and time-stamped.
- MD obtains pharmacy public key #5 from directory.
- MD encrypts script to Key #5.
- MD **E-mails** script to pharmacy.
- Pharmacy decrypts script using Private Key #5.
- Pharmacy **authenticates signatures** and licensed identity; validates message content & integrity using public key #4.
Healthcare Scenario #6

- Physician completes patient bill
- Bills batched, encrypted for HMO using public key #6
- MD connects to HMO
- MD authenticated using key
- Bill file transferred to HMO server
- HMO decrypts batch using private key #6, processes

Healthcare Scenario #7

- Physician connects from home (mobility) to hospital via ISP using VPN to non-Web legacy or Extranet.
- Individual MD authenticated using key #4
- MD role identified using directory
- An encrypted session is opened
- MD allowed access to specific patient results, including images.
- Physician retrieves Lab results
Technical Challenges
Infrastructure

- Healthcare ATP Testbed
- Controlled Bandwidth
- Connectivity to Disparate, Distributed Systems
- Open System, Standards

CHIME Solution:
Network Infrastructure

Wan/LAN High Speed Net
CHIME-Net
Connecticut’s Healthcare Intranet

CHIME-Net ISP Services

- Provide high bandwidth connectivity to the Internet
- Provide point to point scalable Dial-up, Frame Relay, and ATM access for participants.
- Connections: NDC, ENVOY, Blue Cross, Insight
- E-Mail Accounts
- DNS Hosting
- Web Site Hosting
- Network Monitoring/ Performance Reporting
- Network Support
Technical Challenges
Large Scalable Data Sets

- Disparate, Distributed Data sets
- Population studies require comprehensive sets
- There is NO standard “prescription” format
- Each hospital assigns definition and meaning differently.
- Different meaning for same elements between hospitals using similar computer systems.

CHIME Solution: Large Scaleable Data Sets

Distributed Data:
- Provider Rx Formulary
- Provider Rx Scripts
- HMO RX Formulary
- Historical Encounters
- Rx Reference Files
- Practice Guidelines
Challenges: Security

- **Technical Challenges** -
  - Controlled access based on role, identity and privileges
  - Integration of multiple complex technologies and products including NetScape and Internet Explorer
  - Linking Security with Health Care Applications
  - Moving multiple vendors to healthcare standards

- **Operational Challenges** -
  - Preserve integrity and reliability of health Care’s credentialing and accreditation process
  - Accommodate individuals affiliated with more than one institution
  - Ensure uniform trust across all organizations
  - Ensure interoperability across all organizations
  - Jurisdictional variations
  - Transcend industry boundaries (e.g. Providers, Insurers, Employers, Patients)
HIPAA Information Access Requirements

• **Entity Authentication**
  – Unique User Identification (token/biometric)

• **Authorization Controls**
  – Role/Context Based confidentiality

• **Data Authentication**
  – Digital Signature
  – Non-Repudiation
  – Data Integrity

• **Audit Controls**
  – Privacy/logging (Track ALL individuals accessing records)

• **Communications Controls** (encryption)

The User’s Unanswered Questions

• How can we be certain about the identity of the person with whom we are communicating?

• Who can see the information?

• How can we be certain that transactions are conducted with privacy and have not been tampered with?

• Who really signed which components of the document?

• When was it completed?

• Will one party deny, at a later date, that the transaction took place?
CHIME Solution: Security Infrastructure/Standards

Distributed Data:
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- Practice Guidelines

Security Infrastructure/Standards

CHIME-Trust Solution: PKI Components

PKI Components

- Healthcare Specific Policies
- Online Certificate Directory
- Certification Authority
- Distributed Web-Based Registration Authority
- Digital Certificate
- CRL
- Encrypted Message
- Signed Message
- Sending Party
- Relying Party
- Token
- Token
Unique CHIME RA: Healthcare Professional Enrollment

CHIME Attribute Authority (LDAP)

Authorization Organization
(ie Drug Control)

Credential Validation

CHIME CA

Distinguished Name

Registration Authority
(ie Local HR)

Attested Identity
Attributes and Credentials

Public Key

X.509 Certificates

CHIME Attribute Authority (LDAP)

Distinguished Name

Professional Authentication and Signing Certificates

Token

Credentials
ID
Biometrics
Contracts

CHIME Digital Certificate Types

• Patient
• Employee
• Licensed Health Care Professional
• Board Certified Professional

• Organizational (payer, employer)
• Licensed Healthcare facility

Jane Doe, O.T.
Occupational Therapist.

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CHIME-Trust Solution: Security Services

Value added services
- CERT validation
- Prof. registration
- Time stamping

Infrastructure services
- Registration
- Certificate Handling
- Directories
- Card Issuing
- Naming

Basic services
- Key management

Access control
- Security logging
- Identification & authentication

Integrity
- Confidentiality
- Non-repudiation

Services related to the business value or security of document or message exchange, given by agreements or by regulation.

Services which facilitates secure communications in a large scale involving mutual distrustful users.

Services directly related to the secure communication between two users.

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CHIME-Trust Security Model

Root CA
RA

Health System
Healthcare Facility
Healthcare Facility
Empire Blue Cross
Anthem Blue Cross
NDC
NEIC

ISP
Dial-Up Users
ISDN

CHIME
CHIME-Net
ATM/Frame

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Chime-Trust

**Demonstrated success**

- Certificate registration & issuance process
- Inter-organization certificate interoperability
- Directory based access privilege management
- Directory based certificate validation
- Use of certificates for application access control
  - web browser-server protecting web-based clinical services
  - e-mail
  - VPN e.g. access to non-web client-server HIS.
  - Legacy applications (e.g. BCBS Medicare Claims processing)
  - EDI
  - Native HIS

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**Technical Challenges**

**Data Mining**

- Load balancing
- Query optimization
- Complex data mining
- Identify Suitable Engine with Source Code
- Bridging the ‘Gap’ - Extracting the Algorithms
- Parsing of Free text fields
- Ontology for Report Drill Down
- Linking Disparate data sets for longitudinal view
- Multiple EDI transmission formats
- Availability of data
CHIME Solution: Low Cost, Memory Based, Parallel CPU Environment

- Complexity of linking and data mining require high performance
- Need capacity for future growth
- Parallel Intel-based systems
  - Emphasis on RAM memory capacity
  - Adequate disk and CPU capacity
Development of a simple main memory database engine.

- “Simple” of necessity and by design.
- Basic optimizations.
  - Dynamic memory pooling.
  - Non-malloc’ed storage for expression evaluation.
  - Expression “fixing”—a form of common subexpression elimination.
Technical Challenges

• Disparate Data Sources
  – Data from different hospitals are in different format.
  – Merging into a common format.
• Denormalized Data
  – Need to re-normalize the data in order to construct a multi-dimensional model.
• Diverse Population of “User” Needs
  – More views/facts tables
  – Optimization problem and Data explosion

CHIME Solution: Pharmaceutical Data Mining/ Algorithms

Distributed Data:
- Provider Rx Formulary
- Provider Rx Scripts
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- Practice Guidelines
Linking Challenges

- Inconsistent Profile Data
  - Privacy concerns
  - Local formatting
  - Errors and work-arounds
- Complexity
- Calculation of link confidence
  - Lack of link “Gold Standard”
  - Indirect link paths
Indirect Linking

Hospital 1  Hospital 2  Hospital 3  Hospital 4  Hospital 5

A

B

C

D

E

F

G

H

MRN, HIC, Bdate, Sex, Last Name

MRN, SSN, Bdate, Sex

HIC, Bdate, Sex, Last Name

MRN, HIC, Bdate, Sex, Last Name

Weak Link

Stronger Link

Strongest Link

Technical Challenges

- Commercial Optimization Designed for Conventional Relational Database Technology
- How to Interface GUI with ‘The BORG’
- How to Capture Ad Hoc Inquiry for Back-end Processing Optimization
- How to Integrate with Security Infrastructure/PKI for Authentication and Encryption
- Individual vs Statewide benchmarks
- Tools to assist in Budget and Forecasting processes for increasingly expensive products
  - Volume Purchases (last 1000 PT’s w/ Dx)
  - Capability to query specific Dx, Drug, and LOS
Ad-Hoc Reporting

The "Borg" Data Farm aka "The Borg"

ODBC → Data Miner → Web Server → Security Server(s)

Filtered View → Ticket

Administrator

Smart Card

CHIME Solution: CHIME-Reports

- Physician Performance Analysis
- Market Area Payer Analysis
- Product Line Analysis
- Department and Physician Model
- Physicians Hospital/State Comparison
- DRG Market Share
- Inpatient Physician Activity by DRG
- Inpatient Physician Activity by Town
- Annual Case Mix Index
- APR-DRG Risk Mortality/Resource Intensity
Technical Challenge: 
Asthma

- Affects 5-10% of the population
- Most common discharge diagnosis for hospitalized children
- Mortality rate is rising
- Responsible for 25% of school absences
- Costs exceeded $5.8 billion in 1988

Technical Challenge: 
Guideline Complexity

- Choice of appropriate medications depends on
  - Asthma classification (8 variables)
  - Level of control (11 variables)
  - Age
  - Exercise-related symptoms
  - Duration of current treatment
  - Clinician’s strategy preference
- Decrease inappropriate practice variation
- Control spiraling costs
- Resource-intensive, expensive development process
- Little Evidence-based foundation
- Keeping Guidelines current with New Medications
CHIME Solution: Practice Guidelines

Provider Handheld
Guideline Research
Security

Adaptive Parallel Conductor

Distributed Data:
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The Farm:
RAM & CPU

Wan/LAN High Speed Net

Medications

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Technical Challenges

- HMO Formulary proprietary in nature
- Interface to HMO: Numerous and Challenging.
- Alternative to interface with HMO is to communicate through PBMC.
- Political Challenge, PBMC’s have relations with Pharmaceutical Manufacturers.
- NDC Coding Insufficient for Eligibility Checking:
  - Identify product and manufacturer for eligibility
  - Too specific for clinician product selection.

CHIME Solution:
CHIME-Link EDI Applications

- Distributed Data:
  - Provider Rx Formulary
  - Provider Rx Scripts
  - HMO RX Formulary
  - Historical Encounters
  - Rx Reference Files
  - Practice Guidelines

The Farm:
- RAM & CPU
- Wan/LAN High Speed Net
- Guideline Research
- Security
- Adaptive Parallel Conductor
- Provider Handheld
CHIME-Link Applications

- Eligibility Verification
- Inter Agency Referral/Authorization (W10)
- Claims
- Unique Hospital Formulary Lookup
- Unique HMO Formulary (payer/Plan/Benefit Specific)
- Drug/Prescription Eligibility Check, electronic routing
- PKI Directory Lookup
- Nursing Home Bed Availability
- Credentials/Sanctions Checking
- Interactive Reporting

Technical Challenge: Medication Errors and Legibility

Any Prescription
Chime®

Global Impact of Medication Errors

- As many as 1 out of every 25 patients injured.
- Direct cost for inpatient ADE $1900 to $5900. JAMA 1998.
- 28%- 56% of all ADE’s are preventable.
- Many events can be traced back to faulty prescription writing.
- Illegible, incomplete, or suspect medication orders.

CHIME Solution:
Prescription Writing Application

Provider Handheld
Guideline Research
Security

The Farm:
RAM & CPU

Adaptive Parallel Conductor

Distributed Data:
Provider Rx Formulary
Provider Rx Scripts
HMO RX Formulary
Historical Encounters
Rx Reference Files
Practice Guidelines

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Technical Challenge: Handhelds

- Products in Evolution.
- Limited memory today.
- Limited power.
- Limited communications.
- Limited Security
- Accessing Compact Flash
- Demand Paging
- Communications Attachments
- Internalization (UNICODE)

CHIME Solution: Handheld Applications

Provider Handheld

Guideline Research

Security

The Farm:

Wan/LAN High Speed Net

Adaptive Parallel Conductor

Distributed Data:
- Provider Rx Formulary
- Provider Rx Scripts
- HMO RX Formulary
- Historical Encounters
- Rx Reference Files
- Practice Guidelines

RAM & CPU
RxInfo Solutions
Commercialization Opportunities

- High Speed Network Connectivity
- RAM/CPU Farm Technology
- Handheld Query Interface
- Healthcare PKI Security Solutions
- Data Linking Technology
- Time-Zero Handler
- Data Driven Practice Guidelines
- Pharmacy-Outcome Data
- Pharmaco-Clinical Ontology
- Outcome Assignment
- Co-Morbidity Assignment
- EDI Transactions:
  - Eligibility
  - Formulary Checking
  - Prescription Writing

Questions?

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